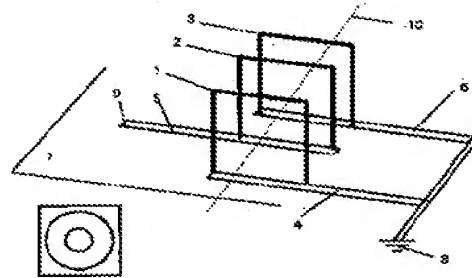


# Method to produce an electrostatic miniaturized lens

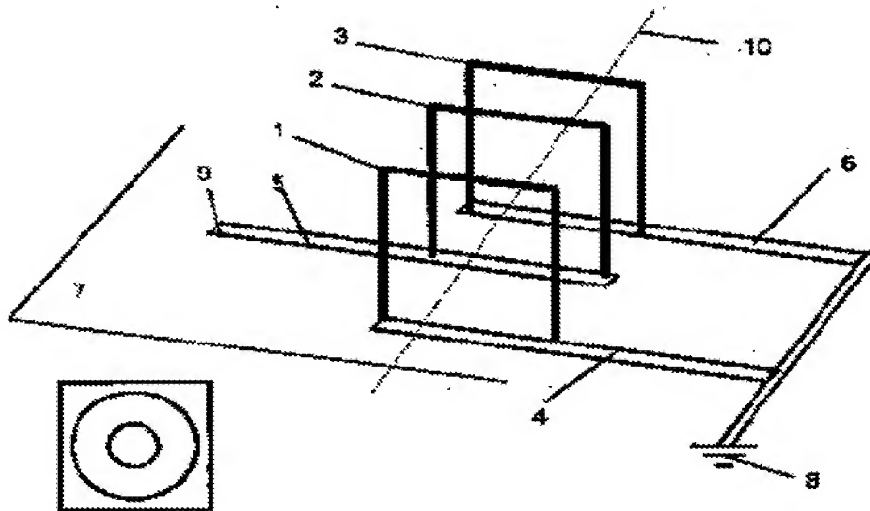
(54) Bezeichnung: Verfahren zur Herstellung einer elektrostatischen Miniaturlinse

(57) Hauptanspruch: Verfahren zur Herstellung einer elektrostatischen Miniaturlinse mit in mehreren Ebenen liegenden elektrostatischen Blenden, dadurch gekennzeichnet, daß die Blenden aus leitfähigen Deponatstrukturen (1, 2, 3, 1', 2', 3') bestehen, die mit Hilfe von korpuskularstrahl-induzierter Depositions-Lithographie auf in Planartechnik lithographisch auf einem isolierenden Substrat erzeugten Spannungszuführungen (4, 5, 6) aufgebaut sind, wobei die Blenden (1, 2, 3, 1', 2', 3') kreisförmig oder polygonförmig hergestellt werden.



Principal claim: Method to produce an electrostatic miniaturized lens using several in differing planes positioned electrostatic apertures, characterized in the way that the apertures consist from conducting deposition structures (1,2,3, 1', 2', 3'), which are produced on conducting lines on an insulating substrate on which voltage feed lines (4,5,6) are produced by planar lithography. The electrostatic apertures are produced using a lithography method which is corpuscular beam induced deposition. The apertures (1,2,3, 1', 2', 3'), can be produced having circular shape or polygonal shape

## Electrostatic miniaturized lens



0001 The invention relates to the method to produce an electrostatic miniature lens having electrostatic apertures in several planes.

0002 Known electrostatic miniature lenses are composed from round openings in metal plates (apertures) having insulating material in between the apertures. Those lenses are described in the book by W. Glaser "Principles of Electron Optics", Springer Verlag Vienna, 19852.

Applications of such lenses are used in microelectronics as immersion lenses in electron sources and in electron tubes.

#### State of the Art

The patent application 4416597 A1 describes a procedure to produce picture element radiation sources for flat panel displays. In this procedure a multitude of miniaturized electron beam field emitters systems is on a having focusing electrodes being built using deposition on metal conducting lines provided by conventional structurization method on a substrate. Electrons emitted from the beam forming systems are accelerated and focused to the target.. The accelerating lens consists from electron emitter electrode, centre electrode having a periodic hole pattern, and target electrode, onto which the picture elements are built in a parallel process simultaneously. The focusing is controlled and measures using secondary radiation detectors , which are placed on the middle electrode facing the target plane. Scanning the picture elements pixels is performed using the focussing electrodes. The target is positioned on a mechanical movable stage which is controlled to move in small raster or large raster movements.

0004 The paper EP 0571 727 A1 describes an ion beam system, which could be used to produce the wires on the conducting via structures, and which is used as prior art in DE 4416597 A1.

#### The task

0005 The task of the invention is to present a procedure which is capable of generating an improved version of the initially described miniaturized electrostatic lens

0006 This task is solved with the miniaturized lens of this invention by using apertures built from conducting deposited structures, which are produced using the corpuscular induced deposition lithography and placed on conducting voltage feed lines prepared on an insulating substrate.

0007 According to the invention the apertures are fabricated in circular shape or having a polygon shape. The latter showed that he deviation of the circular shape has no negative influence on the roundness of the potential in the central area of the aperture, and therefore on the charged particle beam.

0008 Using the production method of corpuscular beam induced deposition lithography very small dimensions of the lenses can be produced with very high precision. This technology became to be known just recently and has been used to produce tips fro scanning force microscopes, and also to characterize lithography systems as well as to structure surfaces. The technology is described by H.W.P. Koops, R. Weiel , D.P. Kern, T.H. Baum in J. Vac. Sci. Technol. B6(1) 1988, 477).

0009 No large requirements are to be employed on the conductivity of the apertures, which are charged to 30 V and no big current shall be flowing. Materials having noble metal crystals like from gold or platinum embedded in a carbonaceous matrix provide sufficiently high conductivity to be used for the production of the miniaturized lenses according to this invention. Instead of noble metals also copper oxide can be used. The miniaturized lens of this invention can have very small dimensions, like 1  $\mu\text{m}$  aperture diameter and 100 nm wired diameter of the different pole wires.

0010 In principle can corpuscular beam induced deposition lithography produce plate like structures, however for the miniaturized lens it is preferred to use rod shaped deposits formed by the deposition technique. Using the improvement of the invention time and material is saved when producing the deposition structures and saving the wanted electron optical characteristics as well.

0011 In another improvement of the method of this invention to produce the miniaturized lens is that at least one of the lens electrodes is composed from closely adjacent built wire electrode rods, which are mechanically and electrically insulated from each other and are each connected to a different voltage supply.

0012 This improvement is advantageous using only rod electrodes which are to be built. In addition the rod shaped electrodes can be supplied with different voltages. With this scheme of supplying individual potentials to the rod electrodes of an aperture multipole potentials can be generated like Dipole, Hexapole, and Octupole potentials, which e.g. is used when compensating lens aberrations, beam deflections and other affections of the electron beam.

0013 With this improvement it is provided that the rod-shaped electrodes are positioned in one plane. With this scheme it is achieved that the potential of the aperture or the miniaturized lens is similar to the potential of a round aperture made from thin metal plates- in addition also different potentials can be fed to the rods.

0014 an advantageous feature of the embodiment is, that at least two rods oppositely build and facing each other can be supplied with voltages from different sources. Are these voltages of different value a deflection of the electron beam is obtained in a simple way. This can be used for instance to construct microelectronic switching elements.

0015 in a further improvement of the invention of the miniaturized lens it is provided, that the apertures located in different planes can be supplied with the same voltage from one source. This improvement is especially suitable and useful to generate a focusing lens having preferred apertures in 3 planes, and having the same potential e.g. ground potential at the outer electrodes apertures, and a different voltage at the middle electrode. The miniaturized lens of the invention however can also be used as an immersion lens. For this mode of operation preferred ground potential is supplied to the left electrodes, and the other two electrodes are supplied with voltages which differ only slightly.

0016 Various examples of the invention are in the figures presented and in the subsequent description in more details explained. The figures show:

0017 Fig. 1 is a first example of a round lens approximated by a fourfold electrode assembly.

0018 Fig.2 is a second example of a round lens approximated by a threefold electrode assembly.

0019 Fig.3 is a third example of an immersion lens approximated by a fourfold electrode assembly.

0020 Fig.4 is a second example of a round lens approximated by a threefold electrode assembly.

0021 Fig.5 is an example in which the aperture in the centre plane of the lens is built with 4 single rods fabricated by deposition and having a fourfold approximation of the round lens potential.

0022 Fig. 6 is a similar example but with threefold approximation.

0023 Fig. 7 shows an aperture with eight cornered field limitation.

0024 Fig 8 shows an lens with six cornered field limitation

0025 Fig. 9. shows an lens with eight cornered field limitation and complete generation of all possible multipole components.

0026 Fig. 10 shows a miniature lens with a middle aperture having eight cornered field limitations and 2 quadratic apertures.

00027 All parts being equal are numbered in the figures with the according reference number

0028 in the example of figure 1 three apertures are provided 1,2,3, consisting from rods, in the following also named pole –wires- and are also provided with a voltage supply 4,5,6. The voltage feeds are planar structures built with lithography on a planar only indicated substrate. The voltage feeds 4,5 are connected to one supply line 8 for ground potential., whereas the voltage feed 5 connects to a separate voltage supply 9.

0029 The axis of the electron beam passing through the lens is indicated by a dashed line

0030 Fig2. shows a lens similar to fig 1, with the apertures 1',2',3' composed each from 3 pole wires. One can see from the in fig.- 1 and fig. 2 schematically shown representations of the potential lines that the area of the electron beam shows the required circular shape as required for distortion free lens action.

0031 Figs 3 and 4 show lenses which have a structure similar to the ones of fig.1 and 2. The voltage feeding lines 4,5,6 however have separate connections to voltage sources 8,9,9'. With this structure the aperture 3 can be grounded, while the apertures 9 and 9' obtain a voltage different from ground, which gives the depicted lens the action of an immersion lens.

0032 In contrast to the miniature lenses depicted in Fig.2 and fig.2, the lenses of figure 5 and fig. 6 have a middle electrode which is composed from several isolated pole wires. The middle electrode of the miniaturized lens after fig. 5 is composed by three pole wires 11,12,13 which each are constructed on a different voltage feed line.14, 15, 16. the additional voltage connector 17 serves a fourth pole wire. A support of the pole wire 11, the wire 18 is removed from the pole wire 13 and from the axis 10, which results in a minor action to the beam of this pole wire 18 with respect to the one of pole wire 13.

0033 In a similar fashion in the miniature lens of fig. 6 two pole wires 21,22 are constructed on voltage feeds 23,24, while the voltage supply line 25 also serves a the third pole wire of the aperture.

0034 Fig.7 and fig.8 each show an aperture having eight-cornered or six cornered field borders. At the aperture of Fig. 7 there are two vertically oriented pole wires 31, 32 constructed on a voltage feed line each. The limitation of the field in the upper and lower part

of the aperture is given by the voltage field line 35 and a pole wire 36, which is supported from the substrate by two wires 37,38 and in addition connected to the voltage source 39 through the wire 38. Positioned under 45°angle are further field limitations in the form of pole wires 40,41,42,43 placed on top of further voltage connectors 44,45,46,47.

0035 For the miniaturized lens according to figure 8 the field limits are formed by pole wires 51,52,53,54, 55 and by one voltage feed line 56. The pole wires 51,52,54,55 are under an angle of 60°positioned on the voltage feed lines 57,58, 59, 60, while the pole wire 53 is held by the wires 61, 62, the latter of which is connected to a voltage line.

0036 The aperture given in figure 9 is built similar to the aperture of Fig. 7. In this example the pole wire 36 is held up only from one pole wire 38. Such a mounting is stable enough for many applications, especially if only small potential differences are used between the adjacent pole wire.

0037 Fig. 9b gives schematically the direction of the action of the tangentially mounted pole wires, which compose the lens field, the naming of the voltage feed lines of fig 9a are used. If all pole wires are supplied with the same voltage, a rotationally symmetric round lens field is generated. If two oppositely positioned pole wires are supplied with a positive and negative deviating voltage than the other wires, a dipole field is generated acting as a deflection or centering field for the lens. In addition it is possible by applying proper voltages to the pole wires to generate a quadrupole field and an octupole field as well as a mixture of the differing fields. A quadrupole field is used e.g. to compensate an astigmatism, an octupole field can be used to help compensate the spherical aberration of the lens.

0038 Fig. 10 shows a lens having the middle electrode being constructed according to fig.8, and having as outer electrodes a square aperture each.

## Claims

1. Procedure to produce an electrostatic miniaturized lens having in several planes positioned electrostatic electrodes, characterized in the way that the aperture are composed by conducting Deposit structures or pole wires ( 1, 2, 3, 1', 2', 3' ) which are produced using corpuscular induced deposition lithography on top of lithographically in planar technology generated voltage feed lines ( 4, 5, 6, ) placed on an insulating substrate, and the apertures ( 1, 2, 3, 1', 2', 3' ) having circular shape or polygon orientation.
2. . Procedure to produce an electrostatic miniaturized lens according to claim 1 characterized in the way that the conducting deposition structures ( 1, 2, 3, 1', 2', 3' ) are produced with the shape of wires.
3. Procedure to produce an miniaturized lens according to claim 1 or 2, characterized in the way that at least one of the apertures is composed using several closely to each other placed rod shaped pole wires ( 11, 12,13, 21, 22, 31, 32, 36, 40, 41, 42, 43, 51, 52, 53, 54, 55), which are insulated with respect to each other and are mechanically and electrically connected to voltage feed lines on the substrate.
4. . Procedure to produce an miniaturized lens according to claim 3, characterized in the way that the lens is produced in a way that the rod shaped electrodes ( 11, 12,13, 21, 22, 31, 32, 36, 40, 41, 42, 43, 51, 52, 53, 54, 55) in general are placed in the same plane.

5. Procedure to produce an miniaturized lens according to claim 3 characterized in the way that the lens is produced in the way that the rod shaped pole wires are produced parallel to the lens axis.

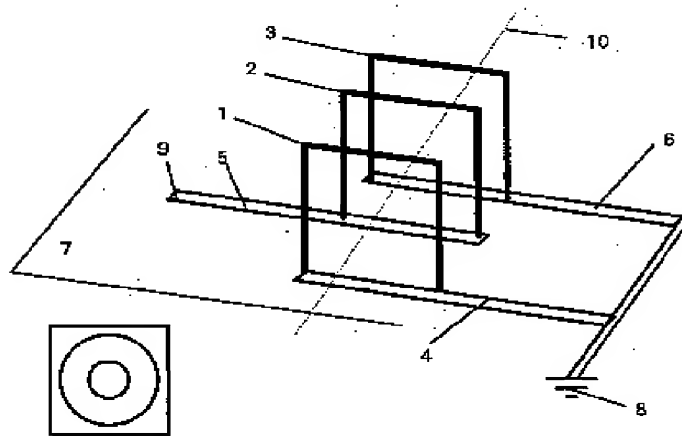
6. Procedure to produce an miniaturized lens according to claims 3 to 5 characterized in the way that the lens is produced in the way that at least two oft the electrodes facing each other (31, 32) have separate voltage feed lines (33,34).

7. Procedure to produce an miniaturized lens according to the preceding claims characterized in the way that the lens is produced in the way that the apertures (1,3, 1', 3') of two planes which include a further plane have a common voltage supply line (8).

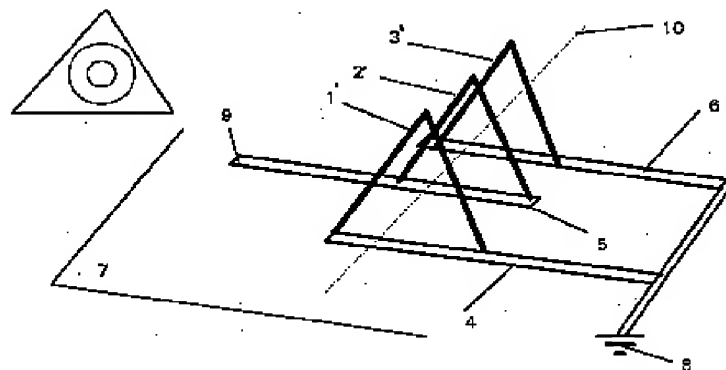
6 pages of drawings follow

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Anhängende Zeichnungen

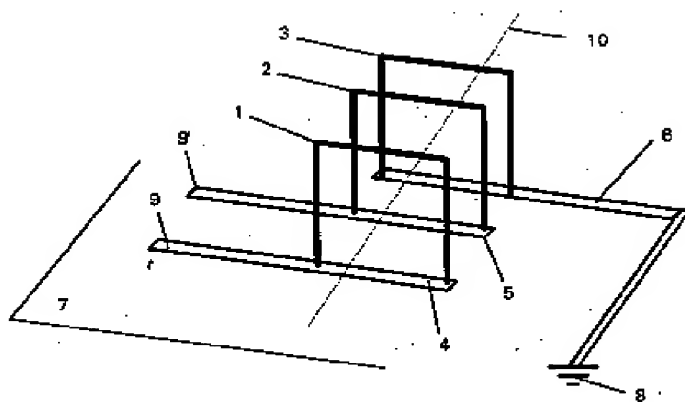


Figur 1

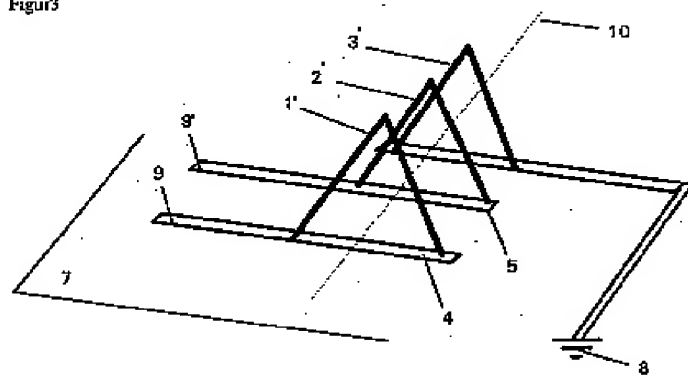


Figur 2

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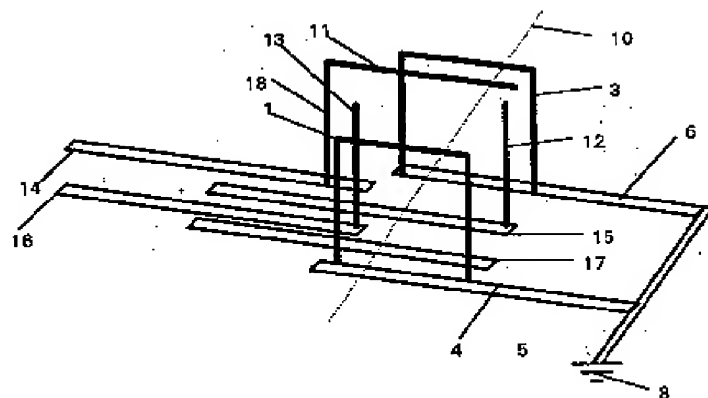


Figur 3

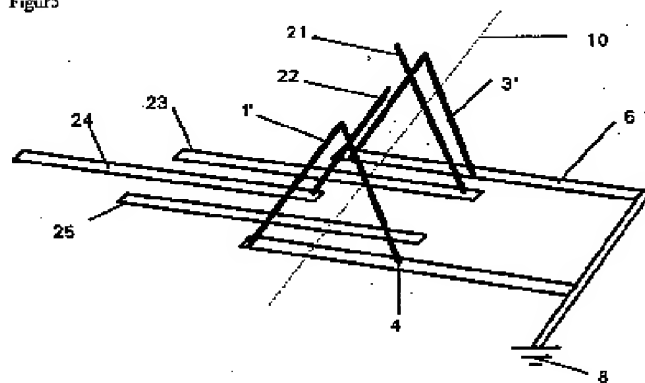


Figur 4

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Figur 5



Figur 6

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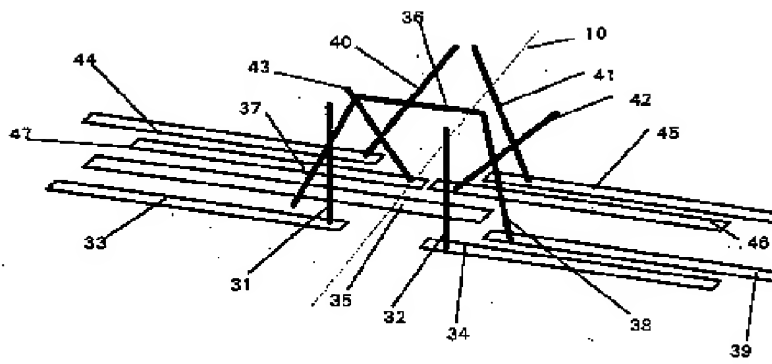


Figure 7

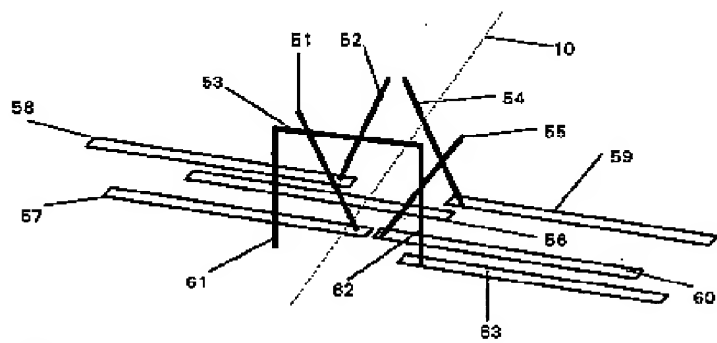
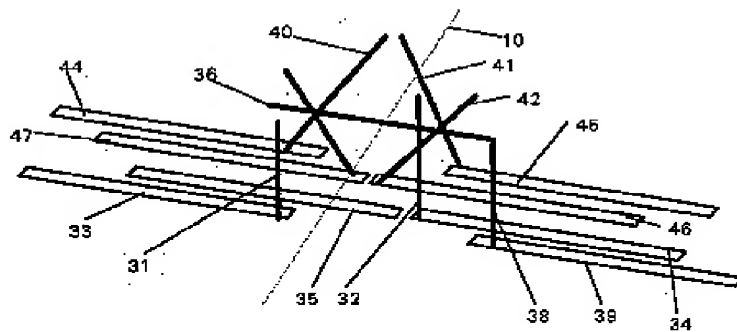
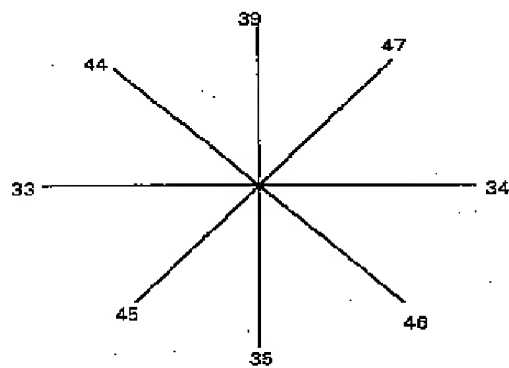


Figure 8

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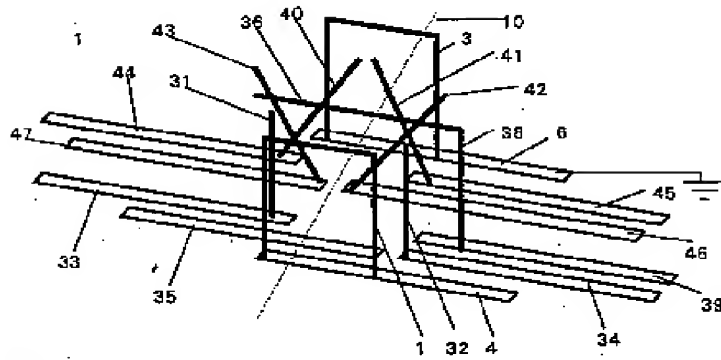


Figur 9a



Figur 9b

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Figur 10